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Experimental Study on the Bench Evaluation Technique of Oils for Oil-Injected Rotary Compressors

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ABSTRACT

The paper discusses a fundamental method of accelerated bench tests for oil-injceted rotary compressor oils. The test compressor, test conditions and evaluated performance indexes of the oils are reasonably determined according to the results of bench tests and field services of the oils.

INTRODUCTION

In past 20 years, rotary compressors were fully developed in west countries. The requirements for various kinds of compressors, especially for rotary screw compressors, sharply increased in recent years. In comparision with reciprocating compressors, Rotary screw compressors take many advantages, such as compactness, lighter weight, easy handing, less vibration and noise, easy maintaince etc. The products of rotary screw compressors in 1992 is about 3 times of those in 1987 in China.

In order to meet the needs of development of rotary oil-injected compressors, Specialized rotary oil-injected compressor oils (R-Lubs) must be provided. So an exactly evaluating method of performance index of R-Lubs is essential to development of high-quality R-Lubs. Our investigation results show that mineral oils are widely used in oil-injected screw compressors made in China. Most of failures in operation of oil-injected rotary compressors are caused by poor lubricants. A Foamy R-Lub may give rise to the failure of the lub/air Separator in a compressor. So as to cause a lot of lubricant to discharge with compressed air. A R-Lub with poor demulsibility may cause the screw rotors and bearings of cmpressors to scuff and wear seriously.

Further investigation shows that, some of R-Lubs, which are refined by different Chinese companies, and whose quality index entirely conform to the

quality index given in ISO 6743-3A, have different performances in services. Some of them can meet the needs of compressor operation and some of the others can't. This gives rise to an argument over ISO 6743-3A. Some researchers[1][2][3] analysed the differences between the real serving conditions of R-Lubs and its analysis processes provided by ISO 6743-3A. A new viewpoint can be approved by many scholars. Various kinds of oil's behavior can be devided into two types, i.e. "static"and "dynamic". The "static"characteristics of a R-Lub, such as viscosity, flash point, TAN (total acid number)etc, agree with its behaviour in services. Some of "dynamic" properties of R-Lubs, such as Demulsibility, foaming resistance, ageing resistance, are not totally correspondent to its behaviour in services. Our experiments proved the viewpoint stated above to be also correct.

In ISO 6743-3A, operational duty grades of rotary oil-injected compressors are classified into 3 kinds, i.e. light(DAG),midium(DAH)and heavy(DAJ)duties. For each duty, specific quality of R-Lubs are refined, light duty products make up over 95% of the total output of rotary oil-injected compressors in China. Therefore, the beneh test technique of DAG oil is discussed in this paper.

Basic procedure of a bench test for a R-Lub can be summarized as follow: a lubricant to be tested is supplied to a specially selected and prepared compressor. Under given operating conditions the R-Lub serves in the compressor for hundreds of hour. For each 60 hours of operation, about 500 grams of the R-Lub is taken out form the compressor to measure its viscosity, TAN, demulsibility ete. The foaming resistance of the R-Lub can be examined through observation of the foam height on the oil level surface in the tank during operation of the compressor.

CONDITIONS OF BENCH TEST

Compressor for Bench Test

In all kinds of rotary compressors, oil-injected screw compressors are most widely used in China. Consequently, it is quite suitable to take a oil-injected screw compressor as the tester of R-Lubs. A single stage and air-cooling compressor can meet the conditions of the tests for R-Lubs. because DAG R-

Lubs is mainly used in the compressors, whose discharge pressur is in the range of 1 Mpa and, whose discharge temperature is about 75℃～85℃. The major parameters of this compressor are listed in Table 1.

Table 1 Major Parameters of the Compressor for Bench Tesr

Model:	oil-injected screw, air-cooling and single stage
Discharge Pressure(MPa):	0.7
Volumetric Flow Rate(m^3/min):	3
Motor Electrical Power(kw):	22
Rotary Speed(r/min):	2960
Discharge Temperature(℃):	75～85

Test Conditions

If the test compressor operates under the specified conditions, thausands of hour will be taken for a test of a R-Lub. This, of coures, can not be accepted by researchers. According to some assumptions[1], the rate of oil deterioration increases by 100% for every 10℃ above 82℃. Thus a accelerated test for R-Lubs can be achieved through raising the compressor's discharge temperature. If this temperature can be maintained in 110℃～114℃, the accelerating factor will be expected to be 7～8 to predict the life expectancy of a R-Lub under field operation conditicns. This relationship results in a test goal of 400 h under the accelerated conditions. Failure of a R-Lub is later defined as an increase of viscosity by 10%, and that of total acidity by 0.4 mg KOH/g.

In order to keep the discharge temperature in the range of 110℃～114℃, the intake temperature of the R-Lub must reach to about 98℃. That is to say, temperature of air-oil mixture in the separator will get over 100℃. It is quite difficult for a common separator whose filter element is made of fiber to bear such high temperature. Therefore, authors reequiped the air-oil separator system and cooling system of the prototype compressor to achieve a accelerated test. The redesigned lubrication system is shown in Figure 1.

Performances to Be Evaluated

Which performances of a R-Lub should be evaluated through bench test depends on the demand of compressor operation for lubricant's properties.

A R-Lub with poor foam resistance often produce a large amount of foam

in the oil tank and the separator of a compressors. This will cause waste of the oil and pollution of the compressed air discharged from the compressor. According to author's experiences in the operation of common oil-injected screw compressors the foam height on the oil level should be limited in 20mm. Otherwise the height of the foam layer seems to be unstable, especially in the condition of high discharge temperature.

Demulsibility of a newly refined R-Lub is often up to standard. But after serving in a compressor for hundreds of hour, the R-Lub's demulsibility is not qualified any more by ISO 6743-3A. For this reason, the demulsibility of a R-Lub should be examined in the processes of the bench test.

In consideration of the influence of a R-Lub on compressor's operation, the demulsibility time of a R-Lub after 200 hours of accelerated beach test should not be twice as large as that of the R-Lub before the test.

Time of Bench Test

On the basis of statistical data the operating time of an oil-injected rotary compressor in field operation is about 4000 to 5000 hours in one year. It is desired that the change of a R-Lub had better be carried out in medium or large servicing term of compressors, in other words, roughly in half a year or in one year. Generally, mineral oils can not serve for a year operation term in compressors. It seems to become a custom for compressor users to change R-Lub in a compressor in half year's medium service term. Consequently it is reasonable for mineral R-Lub to have 3000 hour service life. It is, on the other hand, worthwhile considering the refining and servicice costs of a R—Lub.

The speed of oil deterioration in the accelerated bench test is much faster than that in common field operations. Figure 2 and Figure 3 individually show the viscosity and acidity of two lubricants at different discharge temperatures in the bench tests. Comparing the results in two kinds of test conditions, we can find out that the accelerating factor is about 7.5. That is to say, the oil's deterioration in 400 hours of accelerated test corresponds to that in 3000 hours of field operation.

Service Llfe

The behaviour of oil deterioration are mainly in increases of its viscosity and acidity. As shown in Figure 2 andFigure 3, the acidities of the new R-Lubs

are relatively higher. They gradually come down after putting into test. Hundreds hours later, they begin to rise slowly. until exceeding the limited values. The reason of acidity descent of a R-Lub in the initial time of the bench test is generally considered to be the influences of acid additives. As the specified indexes of R-Lub's service life, the acidity increment of a R—Lub after tested should be less than 0. 4 mg KOH/g, the viscosity inerement should be less than 10%. More increments will result in rapidly increases of compressor's failure.

CONCLUSION

1. Analysed property index of a R-Lub did not entirely conform to the oil performence in field operations. Consequently a beneh test is necessary to exactly evaluate the performence of R—Lubs.
2. A small single stage, air-cooling screw compressor is suitable to test R—Lubs, it can meet the demand of oil evaluation and has the advantages of lower test cost, convenient in maintaince and operation, easy regulation etc.
3. Accelerated bench tests for R-Lub can be achieved through raising the discharge temperature and compression ratio. Accelerating factor of the beneh test can be determined by comparing the performances of the R-Lub between accelerated test and field operation.

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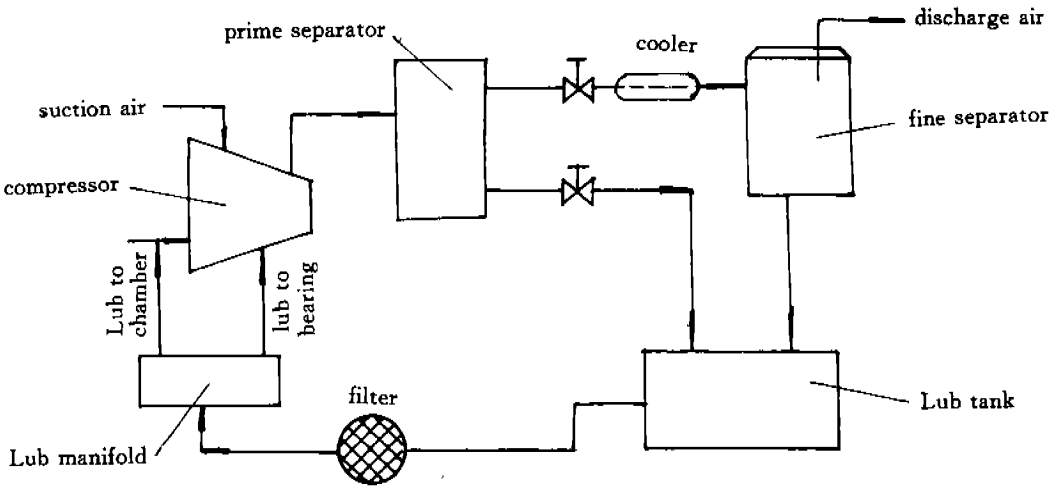

Figure 1 Redesigned air/lub system of the test compressor

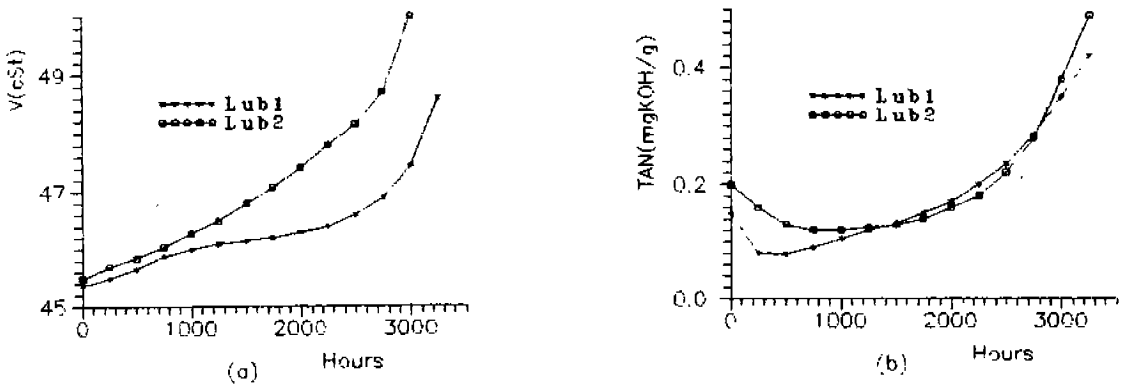

Figure 2 Analysis results of two R-Lubs during field operation

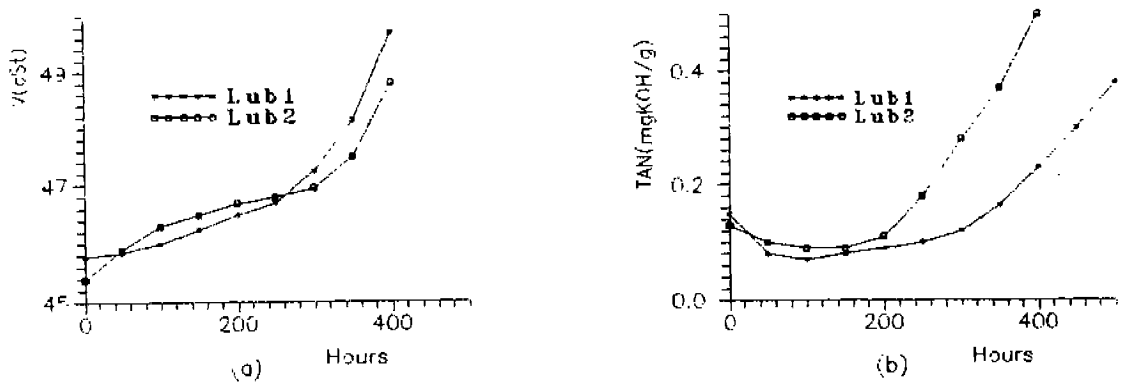

Figure 3 Analysis results of two R-Lubs during accelerated tests